

CHAPTER 21

COMPRESSED AIR SYSTEMS

21-1. Compressed air system

There is no specific way to compress air; however, each system consists of certain typical components. Figures 21-1 through 21-4 provide a depiction for these components and their arrangements. The critical missions of C4ISR facilities require the compressed air start system to be designed adequately to handle two 30-second standby generator start sequences without recharging. More specifics on the requirements can be found in chapter 8 – Diesel Engines.

a. *Components.* Compressed air systems consist of compressor units with drives, controls, intercoolers, and inlet air filtration; compressed air-conditioning equipment consisting of aftercoolers, receivers, filters, separators, traps and drains, and air dryers; and air distribution systems, including piping, valves, control valves, filters, pressure regulators, drains, lubricators, etc.

b. *Applications.* Compressed air is probably one of the most universal operations within a plant environment. It transcends industries, operations, and applications. Compressed air is used to power tools, move conveyers, transport products, and make process applications possible. Considered a power source, compressed air systems are increasingly more reliable and predictable. It is often considered the fourth utility.

21-2. Compressed air system major components

Compressed air systems are comprised of the following major components.

a. *Compressor.* The compressor is the main component of the system. The key issues involved in ensuring the compressor performs as necessary are reliability, cost-effectiveness, ease of operation, and maintainability. Compressor reliability is based on the type of control system, ambient temperature, motor design, and the cooling system.

(1) Modern day use of electronic controls has eliminated many problems associated with mechanical switches and relays. Older pneumatic compressor controls using compressed air taken before the air dryer can prove troublesome because moisture in the air leads to sluggish performance and damage to the compressor. The rubber diaphragms used with these pneumatic control systems are a common weak link in control systems. The control system should be easy to use and provide required data.

(2) The compressor must be capable of operating in ambient temperatures approaching 110-115°F because compressor rooms are five to ten degrees warmer than the outdoor temperature. Higher temperature ratings mean longer, more reliable periods between maintenance.

(3) As a minimum, motor insulation must be class F. Temperatures inside the sound attenuating enclosures for motor and compressors are warmer than the ambient air. Summertime operation gives internal temperatures from 110 to 115°F. Standard Class B insulation motors are designed for a maximum installed temperature of only 104°F.

(4) During operation, the compressor produces a tremendous amount of heat that must be removed. The compressor oil removes some of heat. Lubricated compressors remove even a higher portion of the heat since the oil is in the compression chamber. The oil is then cooled in a forced draft

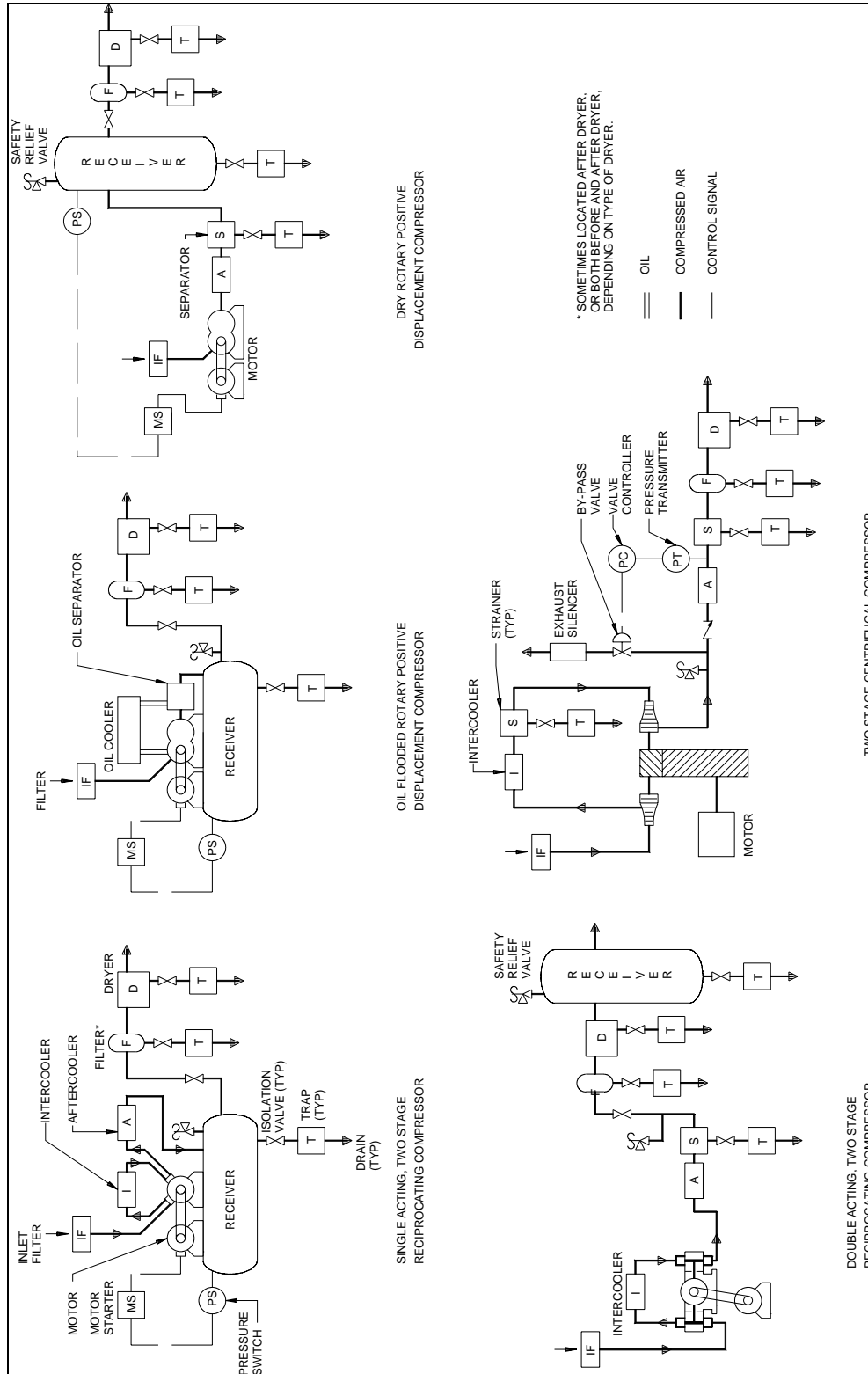


Figure 21-1. Typical air compressor systems

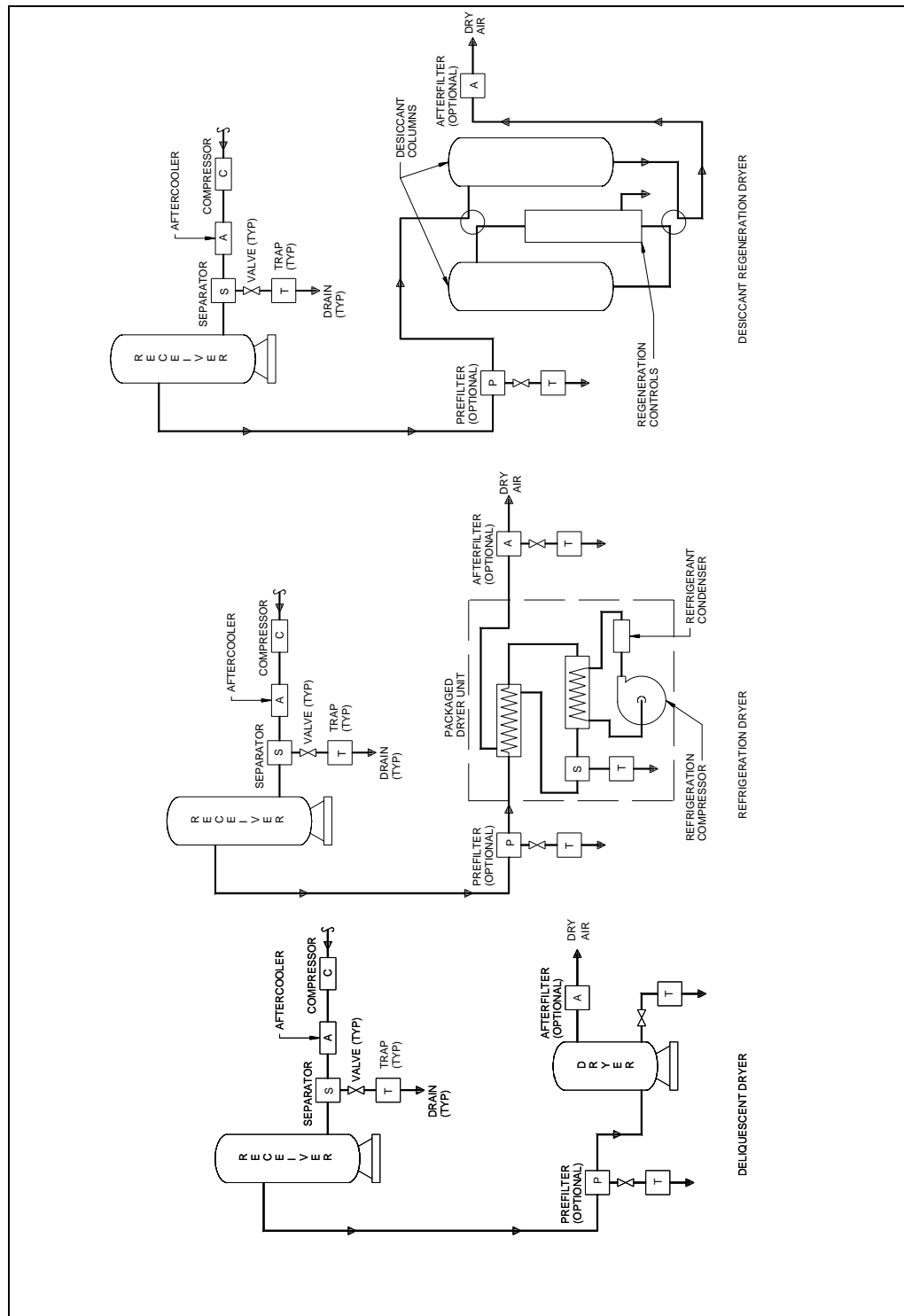


Figure 21-2. Typical air dryers

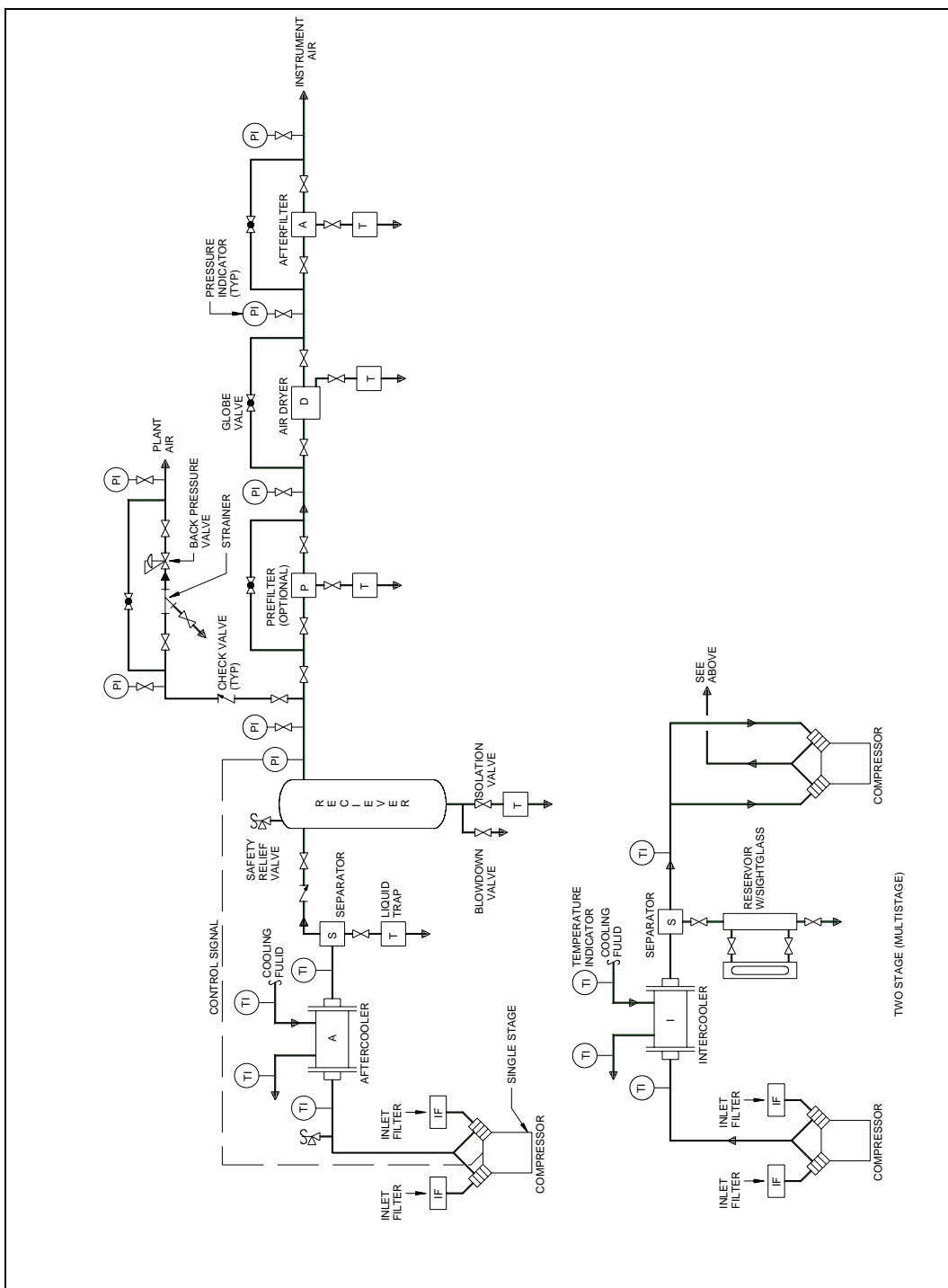


Figure 21-3. Typical air compressor installation

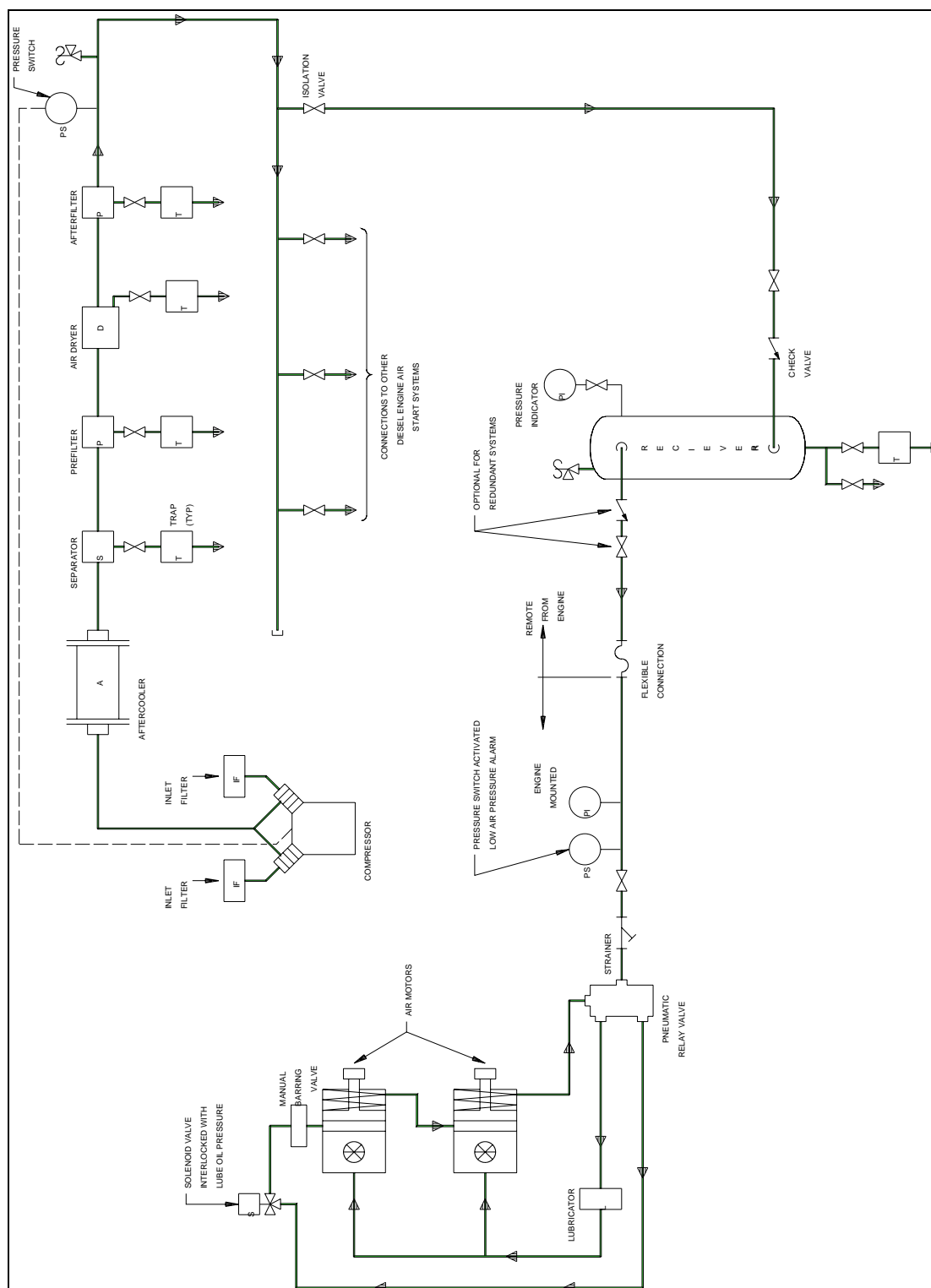


Figure 21-4. Typical engine compressed air starting system

air-cooled heat exchanger. That portion of the heat remaining is removed in intercooler and aftercoolers of sufficient capacity to permit continuous, fully loaded compressor operation in high ambient

temperatures. The aftercooler approach temperature, that is, the temperature difference between the compressed air outlet and ambient air temperature, should be in the 15 to 20°F range.

(5) The compressor should be easily accessible for maintenance. If enclosed, the panels should be easily removed. Leave at least three feet of clearance around the compressor. The primary maintenance items on a compressor are the inlet filter, oil drain, oil fill, motor greasing, condensate traps, and control calibration. Each should be easily accessible. Service indicators help guarantee timely maintenance. In lubricated compressors, the oil travels downstream and must be replenished regularly. Synthetic lubricants provide superior lubricating characteristics, longer service life, and lower vaporization rates. Polyglycols extend changeout intervals to 8,000 hours, have the lowest vaporization rate, and are biodegradable. Oil-free compressors require limited amounts of lubricant for bearings and gears.

b. *Air purification.* The air purification system is an integral part of the process because it ensures that the air produced is of a high quality to preclude deterioration of the piping system and associated valving. The primary functions of the air purification system are to deliver the required air quality, maintain air quality during upsets, and minimize operating costs. Generally, air purification falls into one of three categories: filters, dryers, and receivers.

(1) Filters remove condensed liquids, particulates, and oil vapors. Coalescing filters to remove water and oils have efficiencies from 99.98% at 0.01 micron particle size to 99.9999% at 0.1 micron. The filters should have a maximum wetted pressure drop of 3 to 3.5 psi. The maximum pressure drop, normally 10 psi, determines the service life of these filters. Expect to replace the filter elements every six to twelve months. High-performance coalescing filters require changeout every five years. Although these filters have a higher first cost, the lower pressure drop and reduced energy and maintenance costs provide a simple payback of less than one year. Particulate filters installed downstream of a desiccant dryer should have a different pressure gauge to indicate the condition of filter elements rated for a nominal efficiency of 99.95% at 1 micron particle size and initial pressure drop of 1 psi. Coalescing filters must have high-quality automatic condensate drains. Vapor removal and filters absorb oil vapors with activated charcoal. Location and the oil concentration determine filter element life. Normal pressure drop for a vapor removal filter is 1 psi.

(2) Air dryers are a very important part of the overall system because an aftercooler discharging compressed air at 100°F passes 67 gallons of water per 1,000 standard cubic feet/minute (scfm) per 24 hours. Instrumentation fails when water and lubricant condense as the air is further cooled in the piping system or as the air expands through the orifices. The air exiting the aftercooler is saturated and any further temperature drop results in more condensation. A useful rule of thumb states that "a 20 degree reduction in temperature condenses one half the water vapor in saturated air."

(a) Air dryers reduce the moisture content as measured in terms of a pressure dew point (pDp) that is based on a specific set of inlet conditions to the dryer. Dew point is the temperature at which water vapor condenses -- saturated, 100% relative humidity. Pressure dew point is the dew point of the air at operating pressure. Atmospheric dew point refers to air expanded to atmospheric conditions. To avoid confusion, specify dryer performance in terms of pressure dew point.

(b) The instruments and the lowest expected ambient temperature determine the drying method. The most common dryer is a refrigerated unit that cools the compressed air, condenses water and oil vapors, separates them, and drains them from the system. The "dried" compressed air is then fed to the instrument air system.

(c) Dryer performance is specified as a pressure dew point class that is based on specific inlet and ambient conditions. The lowest pressure dew point class with a refrigerated dryer is Class H. This

class delivers a pressure dew point of 33 to 39°F. Refrigerated dryers should not operate below the Class H range because the water vapor will freeze in the dryer. The highest practical pressure dew point for a refrigerated dryer is 60°F because higher pressure dew points give condensation in downstream piping. In the United States, most dryer manufacturers base the pressure dew point performance on standard conditions: inlet air flow, 100°F inlet air temperature, 100 psig operating pressure, 100°F maximum ambient temperature (air-cooled units), 85°F cooling water temperature (water-cooled units), and 5 psi maximum pressure drop.

(d) Adjust air dryer sizing to account for deviation from standard conditions. For example, elevating the inlet air temperature 10 degrees increases the load on the dryer by more than 25 percent and raises the outlet pressure dew point above 50°F. Maintaining the original 33 to 39°F dew point now requires a dryer 35 percent larger.

(e) Non-cycling and cycling are the two types of refrigerated dryers. On a non-cycling dryer, the refrigeration compressor runs continuously regardless of dryer load. A thermostatic expansion valve and hot gas bypass valve regulate the flow of refrigerant into the heat exchanger to maintain dew point and minimize "freeze-up." Since the unit uses full input power at all times, a non-cycling dryer should be selected for systems with a constant air flow. In cycling dryers, the refrigerant cools an intermediate fluid that cools and "dries" the air. During low-load operation, the refrigeration circuit stops its compressor and restarts it when the fluid temperature rises. The cycling type dryer conserves energy and minimizes dryer freeze-up making cycling dryers the choice with fluctuating air flow and inlet temperatures. Over-sized cycling dryers provide additional drying capacity for future air system upgrades.

c. *Air receivers.* The final major components needed are the air receivers. Air receivers provide storage capacity to prevent rapid compressor cycling; reduce wear and tear on compression module, inlet control system, and motor; eliminate pulsing air flow; avoid overloading purification system with surges in air demand; and damp out the dew point and temperature spikes that follow regeneration. A rule of thumb is to provide a minimum of one gallon of receiver capacity for each cubic foot of compressor flow.

d. *Piping.* Consideration must be given to critical pipe lengths of the air discharge pipe, and certain lengths must be avoided to prevent resonance. The critical lengths vary with the type and size of air compressor, and can be determined from air compressor manufacturers. Consideration will also be given to surge volume between reciprocating compressors and aftercoolers to minimize vibration and wear in the tubes and tube supports or baffles in the aftercoolers. Pulsation dampers or surge bottles at the compressor discharge will increase the installation cost, however, they may reduce maintenance costs because attenuation of discharge pulsations reduces wear and the potential of tube failures.

e. *Safety valves.* A safety valve must be provided between a positive displacement compressor discharge and any block valve or other flow restricting device, as well as between the compressor and an internally finned tube aftercooler. This is particularly true with lubricated compressors. If deposits should clog the aftercooler, proper protection would be afforded. Safety valves should be connected directly into the piping at the pressure point it is sensing, without unnecessary additional piping or tubing. Safety valve discharge should be directed away from personnel areas and traffic lanes.

f. *Other components.* Other components that are part of the system are various control valves, control switches, pressure switches, drains, electrical controls, and wiring.

21-3. Compressed air system interfaces

The compressed air system interfaces with many other systems within the plant or site. Primary interfaces are with the electrical system and the various process systems that the compressed system serves.